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Enabling American Innovation Through a National Safety Framework for Autonomous Vehicles

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Enabling American Innovation Through a National Safety Framework for Autonomous Vehicles

By James C. Owens

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Executive Summary:

This article outlines a comprehensive strategy to modernize the United States' regulatory framework for autonomous vehicles (AVs), emphasizing the dual goals of advancing safety and sustaining American leadership in AV innovation. It lays out a summary case for Federal regulators to pursue a strategy using existing statutory authorities to integrate AVs fully into the new vehicle fleet in a way that promotes safety, accelerates development, and provides the regulatory certainty necessary to make the investments to manufacture those future vehicles at scale.

Introduction

The transportation sector, in many ways, can be seen as doing great. Americans travel more on our roads than ever before, and that helps advance our economy and provide ordinary American families with more liberty to choose where to live, work, and play in their pursuit of happiness than would have been imaginable not that long ago.

But the sector is also facing a growing crisis: our highway system is congested, our roads are aging, there is less expansion of the existing roadway network than before, and America's highway trust is running out of money as red tape expenses rise and as more and more of the fuel taxes that drivers pay every day gets diverted away from the roads they think they are paying for.

There are and have been many smart policy proposals to use time and existing resources more efficiently (*e.g.* streamline infrastructure permitting and construction), or to increase the pool of available resources (*e.g.* unlock the billions of dollars in private investment that is eager to finance new projects). This essay is about a different opportunity to update our roadway network at little or no expense to the public.

Autonomous vehicles ("AVs")—also known as "self-driving cars" that are operated by "Automated Driving Systems" ("ADS")—are a revolutionary, and rapidly maturing, technology that could radically change the way we use and interact with motor vehicles. The potential benefits are enormous: fewer fatal crashes and injuries, less highway congestion, and more access to flexible transportation options for more of our fellow citizens.

Naturally, getting vehicles to drive themselves safely and reliably is not an easy task, and many tens of billions of private investment dollars have been spent developing the technology—and, importantly, much of the development and investment has been in the United States thus far. Significant progress has been made, and AV technology is now reaching an inflection point in terms of its capabilities and rate of continued progress. Broadly speaking, developers are starting to shift from early development to early deployment, and the prospect of near-to-medium term commercialization is becoming ever more likely.

One of the key challenges facing this technology is regulatory in nature. Motor vehicles are highly regulated—and for good reason—and different nations employ different frameworks governing the ways in which automotive innovations can be tested and brought to market. The US framework is generally more open to early-stage innovation than that of other nations, and one consequence of this has been that early AV development (and thus AV investment) thus far has been heavily focused on the US market.

But the industry is not sitting still, and as near- or medium-term commercial deployment comes into view, developers naturally and appropriately begin to focus more on whether and how they will be able to deploy commercial-scale fleets when the time comes.[1] In order to make the investments that are necessary to deploy AV fleets in future, developers need more certainty today about the regulatory requirements and performance expectations that will apply to those future vehicles.

Greater regulatory certainty in this space would benefit all stakeholders. Developers would benefit by knowing in advance what requirements pertain to their products and knowing that they have a clear pathway to commercial-scale deployment if they satisfy those requirements.

The public benefits from regulatory certainty because AVs would have to meet expected levels of performance, because known requirements would help build public confidence that AVs are safe roadway companions, and because more rapid deployment of AVs would move forward the wider societal benefits that the technology promises—saving more lives, avoiding a larger number of injuries, reducing highway congestion, and adding a new level of convenience and access for travelers.

AV development has been inhibited in many countries by the regulatory hurdles associated with slow-moving type-approval regimes, in contrast to the more flexible American framework that provides for easier early stage testing.

Yet some foreign authorities have now issued their own (largely untested) standards, and a global consortium of regulators (via the United Nations) is actively working on publishing an AV performance regulation (that many countries will adopt in whole or part) as early as 2026; as these rules are enacted, the US comparative regulatory advantage could erode, and unless the US responds quickly, there is a significant risk that the locus of AV development (and the attendant economic benefit of billions of dollars of private investment) could shift overseas to countries where the regulatory requirements are more certain.

In response, Federal regulators should articulate a clearer vision for the near- to medium-term integration of AVs in the new (US) vehicle fleet, and then pursue strategies intended to help us get there.

Those strategies should target the fundamental issues all stakeholders (developers and the public alike) are facing: we need safer roads tomorrow but will achieve this only through safe testing today, and we need more legal and regulatory certainty around the expectations of AV performance.

"Federal regulators can and should advance safety and regulatory certainty."

This essay lays out a summary case for Federal regulators to pursue a strategy using existing statutory authorities to integrate AVs fully into the new vehicle fleet in a manner that promotes safety, accelerates development, and provides the regulatory certainty necessary to make the investments to manufacture those future vehicles at scale.

In a nutshell, this essay proposes that Federal regulators can and should advance safety and regulatory certainty (1) by more rapidly (and more visibly) developing *representative* traffic scenarios (and future performance requirements) that will encompass the bulk of traffic situations that an AV should be expected to navigate successfully, (2) by modernizing the existing regulatory requirements to account for novel designs and eliminating outdated requirements *unnecessary for safety*, and (3) by establishing a program in which AV developers may submit and share factual data about unusual scenes (also known as *edge case* scenarios) so that *every* industry participant can benefit from the unusual scenes encountered by *any* developer, with the goal of improving response to unusual scenes while reducing the overall number of real-world test miles that need to be driven by the AV industry as a whole necessary to achieve a given level of performance.

I. Background

To begin, the question has to be asked: why do we want or need autonomous vehicles, and why are companies and investors willing to spend many tens of billions of dollars developing this very complicated technology?

The list of potential benefits is long. Most importantly, AVs could help save thousands of lives and avoid hundreds of thousands of injuries every year. While safety is *the* critical matter, the potential benefits of AVs don't end there: AVs could provide greater freedom and mobility for those unable to drive; they could help reduce traffic congestion and thereby make our existing infrastructure more effective and cost-efficient;[2] they could add convenience for our everyday lives and make goods deliveries and mobility services available to communities that lack sufficient access; they could give commuters back some of their time; and they could allow us to reimagine the role and use of automobiles.

On the key safety issue, the problem is fairly clear: far too many Americans are being killed (more than 40,000) or injured (more than 2.5 million) on our roads every year.

Despite the fact that vehicles are getting progressively safer every year, the decades-long downward trend in fatality rates that started in the 1970s came to an end around 10–15 years ago.

Why? That answer is unfortunately clear: too many people are making too many mistakes, and over the past fifteen years or so those mistakes have been neutralizing the advances we have seen in automotive safety technologies. The National Highway Traffic Safety Administration ("NHTSA") recently found that at least 45% of all fatalities in 2020 involved speeding, alcohol, or failing to wear seatbelts (and those figures do not account for drugs or distraction, which account for a significant but uncertain number of additional fatal crashes).

Most modern cars are well designed from a

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crashworthiness perspective, and they are equipped with systems (like antilock brakes, electronic stability control, and automatic emergency braking) that help to correct for driver error or provide faster emergency response in certain limited instances.

But these systems are not designed to overcome the kinetic energy of high-speed crashes or the sort of reckless steering/acceleration/braking inputs associated with intoxication and distraction. And seat belts can save only those who wear them. Therefore, the apparent paradox—safer vehicles but roughly the same fatality rate—can be explained: we appear to be reaching the *human* limit for traffic safety.

Overcoming the *human* limit naturally calls for one of two general types of responses: either we take more aggressive enforcement action against human drivers, or we look for technological solutions to remove the human-in-the-loop in more substantial ways.

As for the first response, safety enforcement is a necessary element to any effective transportation network, and although the research here is limited, it is both commonsensical and demonstrable that sustained enforcement has a positive impact on dangerous driving. For instance, we have NHTSA's first (Oct. 2020) and second (June 2021) special reports on the tragic and unintentional real-world experiment in traffic safety enforcement during the 2020 pandemic, and one key takeaway is that reducing enforcement measures coincided with more dangerous driving and a consequent rise in the fatality rate.[3]

What we know is that existing enforcement efforts are part of the mixture that has left us with today's unacceptable *status quo*, and while reducing such efforts is likely to lead to significantly worse outcomes, it is highly uncertain whether enhancing enforcement would yield substantial safety improvements in a politically palatable manner.

This leads us to technological solutions. We can and should continue to improve technologies to make vehicles ever more crashworthy, but it is likely that much of the low-hanging fruit has already been plucked when it comes to such conventional crashworthiness technologies, and so future contributions are likely to have a marginal rather than revolutionary impact on the ability of occupants to walk away from crashes. And, of course, occupant protection systems don't generally protect vulnerable road users (although some progress is being made on that front).

The best way to survive a crash, of course, is not to get into a crash in the first place. That leads us to crash avoidance technologies. Traditional crash avoidance technologies focused on improving vehicle performance during emergency maneuvers (e.g. better braking systems), or on enhancing the human driver's situational awareness and control over the vehicle (better lights, mirrors, turn signals, *etc*.).

Newer technologies are taking this a step further by introducing levels of automation to the vehicle's performance, for instance by adding antilock brakes to enhance stopping performance, or electronic stability control to make it more difficult to roll over a vehicle on flat pavement, or automatic emergency braking systems (AEB) to trigger braking responses even without human input. These technologies clearly make vehicles safer, but with the possible exception of AEB, their benefits are already baked into the overall unacceptable safety outcomes that we are experiencing today.

So what is next? One type of newer technology proving to be effective is a suite of driver-assist (but not *autonomous*) technologies referred to as Advanced Driver Assistance Systems (ADAS). AEB is one ADAS component, but there are others such as forward crash warning (FCW), blind spot warning systems (BSW), lane departure warning (LDW), and the like.

It must be stressed that ADAS technologies are *not* autonomous. Far from it: they are designed to assist a *human* driver, typically in situations where human reaction times require augmentation or where the driver may have insufficient situational awareness, but for all ADAS technologies, the human driver remains in command and is responsible for the vehicle's behavior.

Despite their clear limitations, ADAS technologies appear to be having a positive impact on our roadways today. According to an ongoing study funded by NHTSA and performed in cooperation with automotive OEMs, cars equipped with FCW and AEB are significantly less likely to strike another vehicle in a front-to-rear crash (including a high reduction in injury crashes) while FCW systems alone (which only alert the driver to the possibility of a crash) were associated with a fairly small reduction in crash likelihood. This is strongly suggestive of the relative value of an automated technology capable of acting without human intervention, as compared to human-in-the-loop systems.

While ADAS technologies are welcome and promising, it is nevertheless highly unlikely that they alone will solve our traffic safety crisis. First and foremost, many ADAS features are already incorporated into most new vehicles sold today, and as such a significant portion of their overall benefits are already reflected in our overall unacceptable safety outcomes.[4]

Moreover, most of the crashes prevented by ADAS are relatively minor in terms of severity, and it remains to be seen whether ADAS technologies can be developed that could make a material impact on the types of crashes that disproportionately cause death or serious injury.

Recognizing and avoiding or mitigating the most significant types of crash modalities likely requires more capable technologies that can predict the behavior of roadway users and calculate appropriate evasive action. In short, that is what the driver is supposed to do, and that is where we cross the divide between ADAS (in which the technology provides assistance to the human driver) and AVs (in which the technology becomes the driver).

What separates ADAS from autonomous technologies? In general, ADAS is a cheaper and more primitive system, with less powerful computers, less capable sensors, and usually lacking the redundancies that fully autonomous vehicles are expected to have.

ADAS also tries to solve a simpler problem—overcoming human reaction lag or situation awareness limitations in very limited circumstances—than autonomous systems, which seek to replace the human driver for the entire "dynamic driving task." One way to think of the difference is to note that, in general, ADAS provides a "read-and-react" form of decision making, whereas fully automated systems add "predictive" calculations to the driving task.

For instance, a simple automated emergency braking technology can be expected to be reasonably proficient at detecting a stationary object in the road and then activating the brakes unless countermanded by the human driver, while an autonomous system is designed to track every road user within a given envelope, classify each as a particular type of road user (e.g. vehicle, pedestrian, bicyclist, animal, debris), make predictions about the likely trajectories of each such road user (often many times per second), and then map out a course that optimizes for the likely trajectories of these other roadway users within the context of the roadway infrastructure.

In SAE's taxonomy,[5] the autonomous vehicles currently being developed are Levels 3 ("conditional automation") and 4 ("high driving automation") (L3 and L4). These are vehicles that are capable of handling the entire "dynamic driving task" within an operational design domain ("ODD").

The first part ("dynamic driving task") highlights that the ADS is the driver in control of the vehicle and makes all of the executive decisions about what the vehicle should be doing.

As to the second part, an ODD is a kind of time, place, and manner condition, setting forth the geography, weather, and other relevant conditions within which the vehicle has been designed to navigate on its own.

The main difference between L3 and L4 vehicles is that the former relies on a human driver as backup in case the vehicle encounters a situation it cannot handle, whereas an L4 vehicle autonomously executes a "minimal risk maneuver" to resort to a "minimal risk condition," such as pulling over safely.

Where are we in terms of vehicle autonomy development? We're at the very beginning of L3 commercial deployment, as a handful of OEMs have announced plans to sell some L3 vehicles (with relatively constrained capabilities) in the US. *See, e.g.,* Mercedes (in the US); BMW; Volvo; and Honda. And while there are no L4 vehicles for sale today, nevertheless there is a significant amount of ongoing development and testing (and limited but growing amount of commercial deployment for robotaxi or delivery purposes), and it is only a matter of time before the technology is ready to be incorporated into production vehicles if the law allows.

The degree of AV testing ongoing in the US today may surprise some people. NHTSA has published a somewhat outdated map of deployments and testing locations that are voluntarily provided by AV developers, while the California DMV lists companies that hold State AV permits of one kind or another (for quick reference, as of June 2025 there are 30 companies permitted by California to test AVs with a human operator in the vehicle, 6 are permitted to test specified types of driverless vehicles, and 3 are authorized to deploy commercially).

As the California DMV's public data indicates, the number of miles driven by AVs in the state is growing rapidly, more than dou-

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bling from about 4 million miles in 2021 to about 9 million in 2023, including more than 3 million miles operated by driverless vehicles in 2023.[6]

And while the California data is impressive, it is also just the tip of the iceberg: the AV trade association states that autonomous vehicles have driven more than 145 million miles, and one developer notes that it has driven approximately 70 million miles in a rider-only mode (i.e. no driver/operator behind the wheel).

This is supported by anecdotal evidence as well: it is now relatively easy for members of the public to take rides in autonomous vehicles within a given envelope of certain localities, and as a subjective matter, the quality of the ride today is such that perceptions of safety are often improved after experiencing a ride.

While AV technology is still in development, the evidence suggests that it is progressing rapidly. With this in mind, the industry overall is starting to see a shift from early testing to deployment, with commercialization beginning to come into view. This change in the phase of development means that stakeholders' regulatory needs tomorrow are likely to differ from those of yesterday, and that is why it is necessary and appropriate to revisit the US framework at this time.

II. Motor Vehicle Regulations and Today's AV Framework

With the background of motor vehicle safety and the promise of AV technology in mind, let's turn to the legal landscape and how AVs are regulated today.

A. Motor Vehicle Regulatory Framework

First, some background. This isn't the place to fully describe the structure of motor vehicle safety regulation in the United States, but a basic primer will do for our purposes. Motor vehicle safety is subject to a mixture of Federal and State regulation. Until the National Traffic and Motor Vehicle Safety Act of 1966 ("Safety Act"), motor vehicle safety regulation was left to the States, which regulated both the safe operation of vehicles (via driver licensing and traffic code enforcement) and the proper equipment required for motor vehicle registration.

These State equipment regulations were for the main part preempted by Federal Motor Vehicle Safety Standards (FMVSS) that Congress authorized via the Safety Act. NHTSA promulgates FMVSS that must be "practicable, meet the need for motor vehicle safety, and be stated in objective terms," 49 USC 30111(a), and each FMVSS establishes a minimum performance threshold for specific aspects of vehicle or equipment performance. These FMVSS are codified in Part 571 (49 CFR 571 *et seq.*), and they broadly preempt State equipment laws as to the

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matters they cover.

All motor vehicles for operation on public roads must be certified by their manufacturers to satisfy all applicable FMVSS requirements before they can be introduced into interstate commerce (albeit with certain exceptions and exemptions, including some exemption programs that NHTSA has established pursuant to 49 USC 30113 and 30114), and manufacturers may face civil penalties if they certify vehicles that do not conform to all applicable FMVSS unless they did so "despite exercising reasonable care." 49 USC 30112(b)(2).

The FMVSS only cover specific aspects of vehicle or equipment performance—*e.g.* minimum braking standards for light vehicles (FMVSS 135, 49 CFR 571.135), or side impact protection standards (FMVSS 214).

Most of these standards are focused on performance, leaving a certain degree of design flexibility to industry and the market. When some aspect of performance or equipment is not covered by an applicable FMVSS, other Federal or State regulations can step in, and today we see some non-FMVSS Federal requirements (*e.g.* Vehicle Identification Numbers, 49 CFR 565, certification labels, 49 CFR 567, and "if-equipped" standards for Electronic Data Recorders, 49 CFR 563) as well as State laws mandating that vehicles have specific additional equipment (e.g. vehicle horns) or else that certain equipment be installed at first sale (e.g. headlights or brakes) and/or maintained in proper working condition.

These State laws are usually enforced via vehicle registration and inspection mandates, although augmented by a traffic safety enforcement element. Today, States generally regulate driver licensing and vehicle title/registration, establish rules of the road, and set requirements for maintaining certain safety features equipped on vehicles.

And finally, in the absence of FMVSS or other Federal/State regulations, most new automotive technologies can be introduced in new vehicles without the government's imprimatur. That is how electronic stability control and AEB were introduced, long before there was any legal requirement to do so.

B. Today's Legal Landscape for AVs

With this background in mind, we can turn to the ways in which AVs are regulated today. As will be seen, much of the Federal work has been focused on research, policy guidance, FMVSS modernization, exemptions, and recalls, while State efforts have been characterized by modernizing equipment requirements and determining whether and under what conditions AVs should be allowed on public roads.

1. Federal Regulation

The first matter to address is how are AVs regulated at the Federal level today. To begin with, all AVs are subject to the general regulatory requirements pertaining to all motor vehicles. That is, they must be certified to meet all applicable FMVSS or else have an exemption or exception, and as with all vehicles on the roads, NHTSA may exercise its enforcement authority to investigate any aspect of performance that may present an unreasonable risk to motor vehicle safety.

Today there are no FMVSS that address specific aspects of ADS performance. But this does not mean that AVs are outside the scope of NHTSA's regulatory authority. Far from it: manufacturers of AVs for first introduction into commerce must self-certify that the vehicles satisfy all applicable FMVSS. It also means that those who modify vehicles by installing and integrating ADS must not "make inoperative" the safety features installed by the original manufacturer. 49 USC 30122.

And while the existing FMVSS requirements do not pertain to specific aspects of *autonomous* performance, all of the basic performance requirements imposed on motor vehicles nevertheless apply to AVs that are otherwise self-certified by their original manufacturers. Accordingly, all original-equipment AVs that are self-certified, as well as those that are certified as conventional vehicles and subsequently modified by the integration of ADS equipment, can be expected to satisfy all the existing safety standards that apply to any vehicle on the roads.

Some ADS developers seek to build novel types of vehicles. In many cases these novel vehicle types have not been, or perhaps cannot be, certified to meet all applicable FMVSS requirements. This could be because the vehicle has novel features that are outside the FMVSS—such as lacking manual controls that have been interpreted as being required by certain FMVSS—or because the vehicle is still in the prototyping stage requiring further development before certification can be done.

In either case, the manufacturer must have an exemption or exception before the vehicles can be put on roads (or even before they can be imported). NHTSA is unusual among transportation agencies in that, thanks to the structure of the self-certification framework, the agency has relatively limited exemption or pilot program authority. In essence, the agency can create a research and demonstration exemption program (via 49 USC 30114), or it can grant a general exemption for a very limited number of vehicles under certain conditions (via 49 USC 30113), or the manufacturer can make use of one or more specific statutory exceptions to NHTSA's jurisdiction (e.g. the so-called FAST Act exception, 49 USC 30112(b)(10)).

Exemptions are really only necessary if a novel designed vehicle cannot be conformed to the FMVSS. So, the next question is what steps NHTSA has taken to review and modernize the FMVSS to remove requirements *unnecessary to safety* when it comes to an AV.

Over the past decade or so, the agency has been reviewing the FMVSS for this purpose. That process bore fruit officially in 2022 when the agency re-issued a final rule that updated the language of the occupant protection portion of the FMVSS (i.e. the 200-series, 49 CFR 571.200 *et seq.*) to reflect the possibility of novel designs. *See* 87 Fed. Reg. 18,560 (March 30, 2022). This rule made a number of adjustments to the text of the 200-series requirements that acknowledged the possibility, for instance, that a vehicle may not have a human driver, and clarified the logical position that only vehicles designed to carry at least one human are subject to the 200-series rules.

This was a very good start, but there is still work to be done. For instance, a zero-occupant vehicle is no longer required to have a windshield (*see* 49 CFR 571.205), but there is uncertainty about whether the current text of FMVSS 104 (49 CFR 571.104) nevertheless requires *windshield wipers*, a plainly unnecessary component in such a vehicle.

The FMVSS are not intended to be NHTSA's last check against unsafe performance. Rather, NHTSA has rulemaking authority to set performance standards (via the FMVSS) before a vehicle can be introduced into commerce, and broad enforcement authority to address safety defects (i.e. aspects of vehicle or equipment performance that create an unreasonable risk to motor vehicle safety) that are uncovered after first sale, and the agency requires manufacturers to recall such vehicles for a repair (at no cost to the owner).

This authority covers every aspect of a motor vehicle's performance, including vehicle systems subject to FMVSS performance requirements as well as those that are not. NHTSA has investigated safety incidents involving AVs since at least 2018, and over the past several years has expanded those investigations to require (or "influence") manufacturers to declare defects in an AV that malfunctioned.[7]

Furthermore, in 2021 NHTSA used its enforcement authority to issue a broad-based "Standing General Order on Crash Reporting" (or "SGO") that requires AV and ADAS manufacturers to report information about certain traffic safety incidents.[8] Upon collecting the SGO data, the agency began publishing it for public consumption, allowing for a limited window into the performance of ADAS and AV technologies, although the data can be misleading because there is no easy basis to compare AV performance to human-driven vehicles accessible to most observers.[9]

Finally, NHTSA has also been active in developing guidance and research on developing AVs in a safe and responsible manner. The first Federal Automated Vehicles Policy was published in 2016, with updates in 2017 (AV 2.0), 2018 (AV 3.0), 2020 (AV 4.0), and 2021 (Automated Vehicles Comprehensive Plan), and built upon and supplanted the first edition (and eventually expanded the scope beyond DOT and beyond automobiles).

These policy documents broadly provided guidance on automated driving system safety elements, recommended that developers publish Voluntary Safety Self-Assessments, and provided additional best practices for State legislatures and agencies. NHTSA took the guidance one step further by creating the Automated Vehicle Transparency and Engagement for Safe Testing Initiative ("AV TEST").

Although these activities were voluntary in nature, they were intended to help NHTSA use its "bully pulpit" to encourage safer and more responsible practices among developers, and better coordination and mutual learning among a broader group of stakeholders.[10]

Finally, NHTSA has also been very actively involved in researching AV technology and the implications of AVs on our roadways. NHTSA has provided guidance on cybersecurity best practices, human factors research, pedestrian protection methods, and connected vehicle communication systems.

More pertinently, NHTSA has published a number of research papers exploring traffic scenarios that implicate ADAS and even, to a lesser degree, ADS technologies. The

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publication of these sorts of research papers that include traffic scenarios and proposed test procedures is often the first major step toward promulgating a future FMVSS requirement.

For instance, the publication of certain ADAS draft test procedures in 2019, 84 Fed. Reg. 64,405 (Nov. 21, 2019), led directly to the promulgation of the new AEB requirement (FMVSS 127) in 2024. If one wishes to predict what FMVSS will be promulgated in the medium term, one would be well advised to watch NHTSA's research docket carefully.

2. State Authorities

Next, we will briefly look at the actions taken by State governments to regulate autonomous vehicles. In general, the States have taken two types of actions respecting automated vehicle technologies: they have updated their equipment requirements, and they have instituted requirements governing the operation of AVs on their roads.

With respect to the first, many State governments have updated their equipment laws to remove the requirement that AVs have equipment unnecessary to safety, and have taken a variety of measures to govern the circumstances under which AVs can operate on their public roads.

This has been a positive development, removing unnecessary equipment requirements (much along the lines that NHTSA too has been working) without affecting safety. On the operational front, some States have promulgated new laws or regulations specifically authorizing AVs to operate on public roads under certain conditions. Most such States have established a set of up-front requirements (such as insurance requirements or recording devices, *see e.g.*, Tex. Transp. Code 545.454).

In addition, some states have exercised their authority over driving to supervise AV operations. One State in particular stands out—California. That is where a significant fraction of AV testing is taking place today, and it also happens to be the State that has taken the most overtly regulatory approach to AVs.

Pursuant to statutory authority, California DMV has established a reasonably well-designed program in which AV developers must obtain a series of permits to operate on public roads: starting with a permit that requires the vehicle to have a test driver present at all times, advancing to a permit that allows driverless testing, and finally a permit that authorizes commercial activity and deployment outside of the testing context.

By requiring developers to submit applications with evidence sufficient to demonstrate the safety and corporate responsibility necessary to protect the public's safety and earn the public's trust, the California program has been a helpful start to the development of a proper framework of rules and standards governing AV performance on public roads. California also provides

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that registered developers must submit annual mileage and safety-related disengagement data, along with reports of crashes, which DMV subsequently publishes for public consumption.

III. The Case for Regulatory Reform To Enable Innovation

The US has been fortunate to have been central to the development of autonomous vehicles thus far. American companies lead the way in developing, testing, and deploying autonomous vehicles, and by far the largest amount of on-road testing and deployment is happening in the US (although China is catching up quickly).

Many tens of billions of dollars have been invested in developing ADS, and AV companies today are at the forefront of integrating newer artificial intelligence technologies into physical world applications. The stunning early development of ADS technology in the US reflects, in large measure, longstanding regulatory frameworks at the Federal and State levels that enable early stage innovation in the automotive sector.

While the automotive sector is highly regulated in the US and around the rest of the world, the US is effectively unique in providing an environment highly conducive to the development of new safety technologies. And that includes AV technologies.

However, there are reasons to worry that America's early regulatory advantage could become a liability.

At first blush, it may seem odd to suggest that AV development could be harmed by a comparatively supportive regulatory framework that provides opportunity for innovation, but the fact is that the AV industry's needs will shift as the technology advances from early phase testing.

First, the perceived gap in regulatory oversight is incentivizing State governments to fill the vacuum with their own supervisory frameworks, but they are on the whole less well equipped to effectively manage AV development and, moreover, this can lead toward a fragmented and suboptimal 50-state approach.

In addition, as ADS proceeds toward commercialization, AV developers (and the public) will need more concrete performance targets or requirements because the existence of such targets would help industry to allocate resources to the problems that regulators (today or in future) identify as mission critical.

Furthermore, providing a more uniform approach to performance across industry should lead to improving industry-wide performance and, in turn, rising confidence among the traveling public that AVs are acceptable sharers of the roadways. This is of particular concern because the quantum of on-road testing will continue to grow rapidly as the industry nears commercialization.

Safety is paramount, not only because a

major reason why AV developers are themselves in this business is the opportunity to save lives on our highways, but also because public and regulator perception of the AV industry is such that the reputation of all developers is potentially harmed by the mistakes of a few, with the consequent risk of collateral industry-wide fallout from singular incidents.

Finally, the global scene has not been idle. Far from it: global regulators have been diligently working to develop type certification standards for ADS performance, and as those efforts bear fruit, we will see the US comparative regulatory advantage erode.

The (purportedly) near-term promulgation of commercial-scale type certification standards in Europe and elsewhere will create powerful incentives for developers to shift more of their activities to places where the legal and regulatory expectations are more certain.

First, let's look at the global regulatory scene. Most other countries regulate motor vehicles through "type certification," which requires developers to obtain specific government approval before selling or even testing new vehicle technologies (as opposed to the US framework that allows "self-certification" for commercial sales and has far fewer pre-approval requirements in place for testing).

In practice, this means that new technologies in type certification countries cannot be tested or sold until the government develops new standards or establishes pilot programs, and that process is, generally speaking, neither quick nor nimble. This contrast in regulatory approaches has provided the US with a comparative first-mover advantage with respect to ADS technology.

However, this regulatory advantage is not permanent and can be expected to persist only so long as countries requiring type approval have not promulgated the standards for obtaining type approval. And that is what is beginning to change.

Germany issued its own Ordinance for AV type approval in 2022, followed very shortly thereafter by the European Union issuing its own standards. While those standards are as yet largely untested—and as yet still sharply restrict the number of AV vehicles that can obtain approvals—nevertheless these efforts are beginning to clear the way for more AV development in Europe.

Meanwhile, the United Nations Economic Commission for Europe ("UNECE", which is not limited to Europe despite the historical name) promulgates global technical regulations ("GTRs") that influence or are directly incorporated into the automotive safety regulations of many nations around the world. The UNECE has been working toward a GTR for ADS for many years and is now targeting 2026 for finalization after issuing clearer guidance in June 2024. Other nations, such as South Korea, Australia, and Singapore, are also hard at work developing their own bespoke AV frameworks, and they, along with many other nations, may well adopt the UNECE rules when they are eventually finalized.

While final rules for commercial-scale AV deployment are not yet in place in these countries, they are plainly on their way. Within the next few years, and almost certainly before the end of the decade, we can expect that many attractive overseas markets will have type certification rules in place to allow for extensive AV testing and deployment.

Having rules in place will not, by itself, solve the AV riddle for such nations; the substance of those requirements will of course be crucial. The first question will be whether the finalized performance metrics are (a) actually achievable and (b) whether they actually promote safety (as opposed to window dressing lacking scientific rigor).

The second question will be the time and resource burden to obtain the necessary approvals; that is, how will the up-front application and compliance time and expense relate to the near-term commercial benefits.

But, all things being equal, the availability of concrete performance metrics in type certification states is likely to be very attractive to developers who today or in the near future will value greater regulatory certainty. At the very least, the US can expect to face sterner competition for AV development (and the billions of dollars in investment made every year by the AV industry) before the end of the decade, and this suggests that US regulators (Federal and State) will need to think about how best to enable safe development and deployment of ADS if they are to continue to capture the lion's share of AV investment.

Next is the fact that AV technology is entering a new phase of development. As discussed above, AV developers are making impressive headway in solving the core technical challenges, and that is creating a pathway for the industry as a whole to shift away from early research and testing to an early deployment phase, and thence to commercialization.

The exact timing of these phase shifts is uncertain, and different developers are likely to march at different paces with varying degrees of success, but the overall industry-wide trend is clear enough.

As AV developers move closer to deployment and commercialization, market considerations will begin to assert themselves. For instance, the automotive industry, like any heavy industry, faces very high up-front capital costs (it is not cheap to design a vehicle, and even less so to build the physical and supply chain infrastructure necessary to manufacture and assemble motor vehicles), and manufacturers must take a substantial risk today in the hope of selling vehicles many years down the road.

As the overall automotive industry has been reminded lately with the challenges faced by new entrants in the electric vehicle market, it is much easier to hype a vehicle than to build it, and much easier to build it than to sell it at a profit.

Relatedly, designing and building a vehicle is typically a very long process, often taking between about 3 to 8 years from start until the first model rolls off the assembly line. Designs are typically locked in fairly early in the process, and later changes can result in cost overruns and blown deadlines.

Simply put, the auto industry today (and historically) faces high capital costs, thin profit margins, and long timelines, and that is why most new entrants fail and why regulatory certainty is at a premium in the industry.

What applies generally to the automotive industry also applies to AV developers, some of whom will be looking to design and build their own custom vehicles, while others will be looking to integrate their systems in partnership with OEMs; each pathway shares many of the same long-term planning concerns as those who build con-

"As AV developers move closer to deployment and commercialization, market considerations will begin to assert themselves."

ventional autos.

For ADS technology, concerns about what Federal or State laws may require or prohibit in terms of performance and equipage in the near to medium term can undermine the case for making necessary investments in this innovative, life-saving technology at a commercial scale in the US.

The lack of clear regulatory guidelines also makes it more difficult for automakers to determine what is acceptable performance, and for courts to allocate liability appropriately. And, of course, in the absence of a single nationwide standard, there is significant risk that State regulators will be forced (and are being forced) to develop their own standards—often while lacking the technical expertise and sheer resources that NHTSA enjoys.

Automakers are not the only stakeholders who would benefit from greater regulatory certainty. Members of the public, who share their roadways with ADS test vehicles, deserve to have confidence that those vehicles are designed and built with their safety in mind. AV developers, by and large, are an ethical and safety-sensitive lot who incorporate safety principles in their design and testing processes because they understand that safety is not only the chief reason for developing ADS but it is also existential to their companies' future.

Simply put, most developers know that they need to test safely today to deploy their safe vehicles tomorrow. Nevertheless, it is also the case that there are no uniform requirements today against which AV developers, and the general public, can measure AV performance.

This makes it more difficult for developers to target the same performance metrics, and to demonstrate to the public that these newfangled vehicles are safe and trustworthy road companions. AV developers can and should seek to instill public trust by working closely with all key stakeholders in any testing or deployment environment, but this type of intensive community-level engagement is unlikely to scale as the industry moves toward wider deployment and future commercialization.

In short, NHTSA's existing regulatory framework has played a critical role in enabling the development of ADS innovations thus far, but the technology is beginning to enter a new phase of maturity that requires new rules that will enhance regulatory certainty, promote safety and public confidence, and incentivize developers to continue making substantial investments in the US.

IV. The Next Regulatory Framework for AVs

Now that we have addressed the case for updating the US regulatory framework for AVs, the next question is what that new framework might look like.

This essay proposes that NHTSA should adopt a uniform approach to the development of AV regulation that promotes safety, helps to accelerate development, and gener-

> **"Fortunately, the public does not have to wait ten years before NHTSA's efforts can be expected to have a material impact on safety benchmarking."**

ates more regulatory certainty in the near and medium term. This section will first present a vision for what types of regulatory reforms would be helpful in this regard and then provides more strategic detail about each element of the overall framework.

A. A Vision and Strategy for AV Integration

This essay presupposes that safety regulators should want to enable and support innovations that have the prospect of reducing harm to our roadway users.

This includes ADS, which is the most prominent innovation currently in development that has the potential to have a material, even revolutionary, impact on highway safety, congestion, and access.

While regulators have neither the resources nor the expertise to develop ADS technology themselves, nevertheless they play a key role in shaping the course of innovation in this heavily regulated industry. Enabling such innovation requires our regulators to articulate a vision in which ADS technology will be fully integrated into the uniform national motor vehicle framework. Given the rate of technological development and the realistic timeframe for updating the regulations, as a practical matter the vision should be for the first major wave of full integration to be completed in about eight to ten years.

That may sound like a frustratingly long time to wait—and it is—but it is a reasonable reflection of the time and resources necessary to complete NHTSA's scientific, data-dependent approach to promulgating new FMVSS that are practical, sound, and that accurately reflect the capabilities and limitations of the technology.

Fortunately, the public does not have to wait ten years before NHTSA's efforts can be expected to have a material impact on safety benchmarking, for the process of developing new FMVSS is highly iterative, with many opportunities for public input, and in following the process it will materially influence the development of AV technology.

Moreover, as this essay will suggest, NHTSA has additional sub-regulatory tools at its disposal to incentivize safety and accelerate development.

B. Strategies to Achieve this Vision

With this vision in mind, we can turn to the strategy for making it happen. There are two essential goals at hand: promote regulatory certainty to encourage developers to continue investing in this innovative technology in the US and promote safe testing and safe deployment.

This essay proposes a framework of three essential pathways to accomplish these goals. First, NHTSA should develop test procedures and benchmarks for *representative* traffic scenarios that are reasonably expected to have a big impact on safety, with a goal of eventually incorporating such benchmarks into the FMVSS through a highly iterative process involving repeated cycles of publication and feedback, along with a supporting framework to make the future FMVSS practical in the context of AV technology.

Second, NHTSA should address the low-hanging fruit by revisiting and updating the existing FMVSS by removing requirements *not necessary for safety* so as not to impede the development of novel automotive designs that could revolutionize safety, access, and convenience.

And third, NHTSA should establish a safety assurance program that supports the development of an industry library of shared *edge case* traffic scenarios to assist developers in covering the wide range of rare or unusual but potentially repeatable events that occur on our roadways so that potential safety risks can be addressed in a more efficient, accelerated, industry-wide manner.

1. Representative Benchmarks & FMVSS Development

NHTSA's first task should be the creation of *representative* traffic scenarios, followed by the development of appropriate test procedures and benchmarks for performance that can lead to future FMVSS, along with a supporting framework of rules to enable the new FMVSS structure to work. This section will provide (1) a general discussion of how the FMVSS might be deployed to address specific aspects of AV performance, and (2) a proposed high-level regulatory framework that would support this approach.

a. FMVSS and Representative Benchmarks

A representative scenario is a traffic situation that commonly occurs, and the successful navigation of which is a necessary minimum component of future ADS performance.

Put simply, it is the top portion of the bell curve in terms of frequently arising traffic scenarios. The FMVSS today consist of elementary traffic scenarios—for instance, there are more than 20 separate test procedures required for braking performance in FMVSS 135 (49 CFR 571.135), most of which consist of simplified traffic scenarios that address common or representative types of braking performance (*e.g.* brake burnishing, wheel lockup, cold effectiveness, and the like).

No reasonable person would think that the braking scenarios of FMVSS 135 cover all, or even most, braking scenarios in the real world. This is typical of how NHTSA has always approached the FMVSS: NHTSA does not attempt to cover the nearly infinite range of *edge cases* in the FMVSS and instead focuses its standard setting work on the most common and representative situations that vehicles are likely to encounter.

Put differently, the FMVSS cover representative traffic scenarios—the peak of the bell curve and a bit in either direction—while edge cases have historically been addressed through the defect investigation, notification, and recall process.

The same can and should be applied to ADS. As with more ordinary mechanical systems, ADS can be expected to encounter many situations on a routine basis—such as staying in lane, complying with speed limits, recognizing road users, observing and properly responding to traffic signals, making lane changes, making protected and unprotected turns, responding to emergency vehicles, and the like.

The specific situations for specific AVs depend on the ODD identified by the manufacturer—such as highway versus surface street operations, or day/night considerations, or weather such as rain, fog, or snow—but representative scenarios can be articulated for any given ODD. And some such scenarios might be peculiar to AVs, such as scenarios involving the activation of minimal risk maneuvers and minimal risk conditions, or behavior near ODD boundaries, or teleoperation activation.

The number of such scenarios might be expected to grow over time, but the central concept is to identify the set of representative traffic scenarios that will form the core and basis of future FMVSS.

There is one important way in which representative scenarios for AVs might differ from NHTSA's ordinary process for developing FMVSS: many modern FMVSS are designed to address specific safety failure modes that NHTSA has identified in the bulk of traffic data that it collects and analyzes, whereas there is likely to be a core set of representative scenarios for AVs that are intended to confirm safe AV performance in situations where human drivers are behaving safely.

Put simply, AV performance goals are likely to encompass both safer-than-human performance in human failure scenarios, as well as as-safe-as-human performance in human success scenarios.

This likely means that NHTSA should develop a kind of "AV Driver's License" that functions much as any human licensing; after all, applicants for driving licenses are not subjected to an infinite number of edge case scenarios, but rather are expected to pass a core set of simple representative scenarios to demonstrate basic competency to drive.

In this, it is the State DOTs rather than NHTSA that have the right expertise, and so the Federal agency should seek guidance and support from its State counterparts in identifying the representative scenarios that should be considered for this part of the project.

The number of tests will likely rise over time, but in essence the goal remains the same: identify representative and highly common scenarios (human-fail and human-pass) that we as a society should expect AVs to be reasonably competent at performing. Such an "AV Driver's License" would augment, not replace, the additional representative traffic scenarios designed to mitigate known pre-crash typologies.

As can be inferred from the discussion above, while ADS represent a revolutionary technology, the performance of the AV system is still capable of being addressed with NHTSA's existing statutory tools and traditional methods. Each representative traffic scenario is a bit like the brake tests of FMVSS 135 in that the agency can be expected to perform research and collect data on which scenarios would have the most impact on traffic safety, then develop test procedures to isolate that aspect of performance in an objective and repeatable manner, followed by the development of appropriate performance criteria.

There might be only one test for simpler situations (perhaps proper following distance, or speed limit compliance), or a large

"NHTSA should develop a kind of AV Driver's License that functions much as any human licensing."

number of representative scenarios for more complicated scenes (such as intersections and crosswalks). The technology might be new, but the concept of representative situations is not.

Over time, NHTSA can and should add to the library of testable scenarios—it would be fanciful and self-defeating to expect that all scenarios should be ready at once, like Athena springing from Zeus's head. Instead, the agency should focus on developing the first tranche of core scenarios first, with the expectation that additional waves of tests and benchmarks will follow as they are identified and developed.

NHTSA's research team is already generally working on this type of project, and so the question is what additional resources or leadership input are necessary to focus the team on completing this work as promptly as possible.

The first step—identifying the general traffic scenarios (or at least the first batch)—should be concluded fairly quickly, at which point the candidates can be published for public comment. In fact, NHTSA has already developed a number of traffic test scenarios that could be used as the foundation for this project.[11]

Once that is done, NHTSA can review the comments and finalize the first set of scenarios for publication. The next step would be for the agency, working with researchers and stakeholders, to develop objective and repeatable test procedures that isolate the specific aspect of performance at issue in a given scenario.

And once that is done, NHTSA again would publish the proposed test procedures for public comment. Upon reviewing the comments, NHTSA would then be in position to publish the final set of proposed test procedures for the first batch of representative traffic scenarios.

Finally, using these test procedures, the agency would conduct research to determine the proper performance metric that meets the FMVSS statutory requirements and should apply to a given test procedure. Upon identifying such metrics, the agency would be expected to publish an NPRM proposing to incorporate the given test procedures and performance metrics into a new (or updated) FMVSS.

This too would be followed by a review of public comments, and then the finalization of the FMVSS. All in all, this process can be expected to take about a decade, and for that reason the agency should commence its work in earnest as soon as practicable.

While the final FMVSS requirements would likely not be finalized for several years, the involved process of developing each of the future proposed standards has the added benefit in that the safety benefits will be largely achieved long before the standards are promulgated.

AV developers will be watching closely and can be expected to tailor their systems to satisfy the anticipated performance metrics long before the FMVSS is finalized. In fact, this has been NHTSA's experience with most

> **"NHTSA should focus on making visible and sustained progress on developing the representative traffic scenarios and test procedures that will become the basis ADS performance standards."**

of its recent FMVSS rulemakings.

For instance, by the time NHTSA finalized its standards for electronic stability control and rearview display, most of the new vehicle fleet was already in compliance. That is not accidental: NHTSA's process, when it is done properly, is transparent, rational, and data-driven, and automakers have a vested interest in participating in the rulemaking and updating their vehicles as quickly as feasible.

The same can be expected of the AV industry. As NHTSA begins the hard work of developing traffic scenarios and then test procedures, AV developers can be expected to participate and observe, and as a result their systems are likely to meet the future performance requirements long before the final rules are published.

That means that AV developers, and the public at large, will start to enjoy the added safety benefit and regulatory certainty associated with clearer legal requirements many years before the laws are in effect.

In short, NHTSA should focus its efforts on making visible and sustained progress on developing the representative traffic scenarios and test procedures that will become the basis of future ADS performance standards.

This process is more conventional and simpler than has been conceived, and the agency should recognize that an FMVSS is more effective and practical for a more limited number of commonly encountered representative traffic scenarios rather than the nearly infinite number of extremely rare edge cases.

In so doing, NHTSA would promote safety and regulatory certainty, and its highly iterative process would help the agency navigate toward the first set of core FMVSS performance metrics for ADS.

b. Proposed Regulatory Framework for AV Regulation

After addressing the general concept for applying the existing FMVSS tools to AVs, the next step is to share a high-level proposal for what this framework might look like, and what regulatory updates may be needed.

There are three essential issues here: (i) how the FMVSS might be applied to AVs, (ii) what supporting rules may be necessary to make this approach practicable, and (iii) what to do in the interim while the FMVSS are finalized.

(i) Proposal for Structuring FMVSS to AVs

As discussed above, all new vehicles must be certified by their manufacturer to meet all *applicable* FMVSS. The word "applicable" is crucial, because vehicles come in many shapes and sizes, and not all FMVSS are necessarily applicable to all vehicles.

In this context, NHTSA should consider creating a category of vehicles, called Automated Driving Systems or something like it, to which these AV-specific FMVSS would apply. Then NHTSA might establish specifically defined ODDs (both environmental—e.g. dry or rain, or day, dusk, and night—and geographic—e.g. urban streets or highways) and promulgate FMVSS with specific test conditions and performance requirements associated with each ODD.

That way, as will be discussed below, manufacturers would certify their AVs to specifically selected ODDs, and NHTSA would have established minimum performance requirements for each. For instance, the intersection tests below could be run under daylight or night conditions, in dry, rain, fog, or even snow, depending on which environmental ODDs the manufacturer elects to certify to.

There is one additional item that will be addressed in greater detail below, but is worth raising here as well: there is reason to believe that NHTSA is concerned that AVs can defeat FMVSS testing by the simple expedient of learning the test procedure, a sort of AV-equivalent to the notorious “Dieselgate” that caused a stir in the environmental testing world.

That is a real and genuine concern and must be addressed by any regulatory system for AVs. Fortunately, the answer is fairly straightforward and readily available already.[12] Under the terms of 49 CFR 571.4:

> The word *any*, used in connection with a range of values or set of items in the requirements, conditions, and procedures of the standards or regulations in this chapter, means generally the totality of the items or values, any one of which may be selected by the Administration for testing, except where clearly specified otherwise.

In practice, this means that NHTSA can establish a range of performance requirements and test conditions (for each FMVSS and each ODD) that would allow NHTSA to vary the test conditions in a way that would impair or prevent the autonomy system from simply learning and defeating the test.

For instance, NHTSA could establish a test for performance at, say, an intersection, but the test conditions might allow for 2-way, 3-way, 4-way or larger intersections, with different ranges and locations of other roadway test agents. NHTSA might even consider creating tests that can overlap with other tests, such that a particular roadway test (say, for a pedestrian at a crosswalk) might overlap with an intersection test in different ways.

With that background, this essay proposes two essential categories of AV-specific FMVSS, each of which would necessarily contain a variety of different requirements and tests.

Those categories are: (1) core dynamic requirements; and (2) multiple agent dynamic requirements. Each will be addressed in turn.

(1) *Core Dynamic Performance Requirements.*

First, NHTSA should consider establishing performance requirements that address the movement and operation of AVs on roads. As a first necessary step, NHTSA should create a set of core dynamic requirements for the minimum safe performance of AVs on roadway infrastructure.

The intent is for these core requirements to be conducted on infrastructure without adding other roadway agents; those additional requirements would be addressed in the next set of FMVSS ("Multiple Agent Dynamic Requirements"). The reasoning for this is that in order to establish overall minimum performance requirements for safe AV operations on public roadways, it is important to first determine that AVs can safely navigate the wide variety of roadway infrastructure (as determined by NHTSA) by isolating their performance on "empty" test roads, followed by adding a layer of "other agents" to separately determine whether the AVs can also navigate such infrastructure in the much more dynamic scenarios that routinely occur on public roads.

The intent is that NHTSA would identify a series of geographic ODD requirements, and manufacturers would certify to the specific ODDs that their system is designed to navigate. This might mean, for example, that there would be highway-only vehicles not tested against certain types of roadway infrastructure (e.g. roundabouts or school zones).

Some examples of "core dynamic" requirements might be:

- *Roadway Driving.* The intent of these requirements would be to ascertain performance requirements for AVs to stay in lane, identify curbs and lanes appropriately, maintain speed within the legal limits, navigate roadway curves, address street parking and bike lanes, comply with traffic signs and lights, and navigate complex roadway geometries such as medians, center turn lanes, adding or subtracting lanes, roads without lanes, cross-walks, (static) school zones, faded roadway paint, construction cones, railroad crossings, and the like.
- *Lane Changes.* The intent of this category of requirements would be to establish performance requirements for vehicles to make lane changes. In a static test environment, the intent would be to test for lane change capabilities in general, along with ensuring that lane changes are conducted in accordance with traffic laws, including tests such as painted or dashed painted lane dividers.
- *Intersections.* Next are a category of requirements around intersection performance. In a static environment, this is intended to address performance requirements for successfully navigating protected and unprotected turns, turn lanes, traffic control signs and lights, identifying right of way, addressing shared center turn lanes, addressing median strips, and the like.
- *Highway Ramps and Merges.* A variety of lane changes, these requirements would focus on identifying and successfully navigating on and off ramps to controlled access highways.
- *Highway Driving.* Similar to roadway driving, these requirements would test for performance on controlled access highways, including operating at higher speeds, maintaining lane integrity around curves, identifying on and off ramps, identifying and navigating shifting lanes, and identifying bridge height restrictions.
- *Rural Roadway.* These requirements might identify and address infrastructure complexities unique or common to rural areas, such as single-lane bridges, narrow roads, drop-offs instead of curbs, unpaved roads, steep slopes with attendant acceleration and braking challenges, runaway vehicle ramps, and the like.
- *Emergency Vehicles.* These requirements

> **"NHTSA should consider establishing performance requirements that address the movement and operation of AVs on roads."**

might address the detection, identification, and compliant avoidance of emergency vehicles.

- *Dynamic Infrastructure.* These requirements could address the range of dynamic elements of infrastructure other than regular traffic signals, such as pedestrian crosswalk warnings, active school zones, flashing traffic signals, traffic cones, and human traffic controllers.

(2) *Multiple Agent Dynamic Requirements.*

After identifying roadway infrastructures, establishing test conditions and procedures, and then performance requirements for AV operations, NHTSA can then supplement the static or core dynamic requirements by adding roadway agents.

Such agents would define the testing performance of other vehicles, pedestrians, bicyclists and motorcyclists, scooters and skateboards, animals, and changeable static elements such as debris, trees, and parked cars, to determine the requirements for AVs to avoid collisions or conflicts, or mitigate collisions or conflicts that cannot be avoided.

In essence, this category of requirements would focus on developing testing metrics for such agents and then establishing overall test conditions and procedures that allow for a variety of such agents to be added into the dynamic tests for AVs. To put it more simply, NHTSA could establish requirements that give the testing facilities flexibility to add one or more roadway agents at a wide range of locations within a given infrastructure test.

As an example, child pedestrian dummies could be added to cross in school zones, or multiple oncoming and turning test cars could be added to an intersection test, or a bicyclist dummy could approach the vehicle from the bike lane, or a large animal test dummy could emerge from a roadside occlusion, and so forth.

Done right, this approach could allow for sufficient flexibility to test AVs under a variety of challenging circumstances, with sufficient randomness to eliminate concerns about "teaching to the test". And, of course, the intent is that each performance requirement would be susceptible to being tested under each environmental ODD condition.

(ii) Supporting Regulatory Framework

In addition to establishing categories of performance requirements for AV-specific FMVSS, it would be necessary to create a regulatory superstructure to make the application of FMVSS to AVs more feasible. This essay makes several suggestions in that regard, as follows:

(1) AV Manufacturer Registration & Digital Presence

The first suggestion is for NHTSA to establish requirements for manufacturers of AVs or AV-specific equipment (e.g. AV-specific lidar and the like) to register as such with the agency.

This would provide the agency with more visibility into the manufacturing and AV-specific supply chain, and would make it possi-

> **"This approach could allow for sufficient flexibility to test AVs under a variety of challenging circumstances, with sufficient randomness to eliminate concerns about teaching to the test."**

ble to establish an official digital presence for each such entity so that consumers can gain more insight into products being offered for sale, and for the provision of user manuals, training, and regulatory specific communications (e.g. communications about defects or ODD changes). This is not a heavy lift and should be relatively non-controversial as well.

(2) Self-Certification & Digital Certificates

Next, some modifications are likely to be needed to the self-certification process to accommodate the unique features and needs of AVs. Under today's Part 567 requirements, vehicle (and, where applicable, equipment) manufacturers self-certify that the vehicle (or equipment) meets all applicable FMVSS requirements in effect as of that time and then apply a certification label to the doorjamb of the vehicle (or in the appropriate locations for equipment certification).

That process has worked well for most of NHTSA's existence, and the presence of the certification label is a powerful indication that the vehicle meets all then-applicable requirements. But times are changing.

While it was appropriate to affix a physical label to vehicles defined mostly by their hardware systems (and are thus less likely to be modified by manufacturers post-sale except for specific repairs), today's vehicles are increasingly defined by software, and AVs are much more so.

In effect, this means that vehicles are going to increasingly resemble consumer products like smart phones, in which a consumer acquires a particular hardware platform with the expectation that the software will be updated and improved regularly, rather than as simple mechanical devices whose capabilities are more or less fixed at the time of manufacture. The question then becomes: is this compatible with the incumbent rules involving one-time physical labels?

The suggestion here is that NHTSA can better accommodate this software-defined future by establishing digital certificate labels in addition to the physical ones. Part 567 could be updated to provide for the affixing of a physical certificate label at the time of manufacture but allow for digital certificates if/when the certificate needs to be altered in the future. These digital certificates could be located on the AV manufacturer registration landing pages maintained by NHTSA and would greatly enhance a consumer's ability to understand the safe operational parameters of a given vehicle.

(3) Updates via Alteration Labels and Make Inoperative Prohibitions

Finally, to make this system of accommodating vehicle upgrades work more effectively, NHTSA could tap into the existing process for so-called alteration labels.

Under 49 CFR 567.7, manufacturers can alter a previously certified vehicle, and in so doing must affix a (physical) alteration label reflecting the change. This process can be updated to allow for AV-specific upgrades in an efficient and effective manner by allowing AV registered manufacturers to issue a digital alteration certificate online.

This may be necessary if, for example, NHTSA adopts an FMVSS regime for AVs oriented toward ODDs. To do this, the manufacturer would have to certify that the vehicle met all applicable FMVSS requirements for each relevant ODD (the new ones and the pre-existing ones) in effect at the time of alteration.

For example, a manufacturer might certify that the vehicle in question meets all AV-specific FMVSS requirements applicable to, say, an environmental ODD such as dry weather, and that limitation might be communicated on the physical certificate, but that same manufacturer subsequently might upgrade the environmental ODD to include, say, light or heavy rain (via certifying that the vehicle meets all FMVSS requirements applicable to dry and rain ODDs).

This type of regime would protect consumer interests by ensuring that vehicles meet all applicable safety requirements established by NHTSA, while at the same time providing consumers with more value by allowing industry to upgrade those same features in a safe and regulated manner.

As an additional supporting feature, NHTSA could also look to the so-called "make inoperative" provisions of 49 USC 30122. In relevant part, this statute prohibits vehicle manufacturers (along with most other professional auto repairers) from making inoperative "any part of a device or element of design installed on or in a motor vehicle or motor vehicle equipment in compliance with an applicable motor vehicle safety standard." NHTSA can provide exemptions from this rule, and today has a suboptimal regime under Part 595 in which exemptions from the "make inoperative" provisions are allowed to accommodate persons with disabilities.[13]

For AVs in particular, NHTSA should consider updating Part 595 by promulgating an interpretive rule that, instead of providing exemptions, would clarify that any ODD limits placed on AVs during certification constitute safety elements such to the statutory prohibition, such that any manufacturer upgrading an AV's ODD would violate the law unless the new digital alteration label process were to be used.

This in turn would help ensure that ODD modifications are done in a way that meet the relevant FMVSS performance requirements, while in turn providing for far greater flexibility for manufacturers to upgrade their vehicles.

(4) FMVSS Testing

The last major item that might require some modification to the existing regulatory process involves vehicle testing—that is, how would NHTSA reasonably be expected to test certified autonomous vehicles to determine whether they conform to the FMVSS.

Recall that NHTSA has a "trust but verify" approach to compliance—manufacturers are trusted to self-certify accurately, and NHTSA encourages good behavior by randomly testing an assortment of new models every year.

But AVs bring a special challenge to the testing environment. Not only are they likely going to be more difficult to acquire (at least until personal autonomous vehicles are more widely available), but the limits on ODDs (environmental and geographic) may well mean that it would not be possible to conduct tests in many places.

Given that, how might NHTSA approach

testing in an AV environment?

This essay suggests that NHTSA can establish a fairly simple test facility regulation, which would identify the environmental ODD testing capabilities that would establish which facilities are able to test which environmental ODDs.

Facilities would simply self-certify that they are capable of conducting certain environmental tests, and NHTSA could work with them in much the same way as it works with conventional test facilities today.

Manufacturers of AVs could then be required to identify the certified facilities where their vehicles can be tested. This of course would mean that AV manufacturers would be expected to perform a sufficient amount of mapping at such facilities to enable their AVs to perform as designed.

While this would not be without cost, it is expected that such cost would be fairly small and possibly even *de minimis* in relation to the value of being able to certify AVs to meet Federal standards. Using this framework, NHTSA could be expected to conduct fairly ordinary FMVSS compliance testing of AVs.

There is an additional pathway that could supplement this approach. NHTSA could choose to test AVs within the actual ODDs on public roads.

That is, NHTSA could obtain an AV and bring it to a roadway identified by the AV manufacturer as being within the geographic ODD, and then coordinate with local authorities to ensure that testing could be done in a safe and responsible manner (which might mean temporarily closing a street for a few minutes or hours).

While this approach would not be easily susceptible to most of the environmental ODD conditions, it would provide the agency with an additional avenue for testing the vehicle's operations in the real world.

(iii) Interim Demonstration Program

Assuming NHTSA undertakes the difficult but important task of establishing FMVSS test procedures and performance metrics to govern specific aspects of AV performance, the next question will inevitably be: what will or should happen during the ~10 years until the first wave of such rules is substantially complete.

While it is certainly the case that, as suggested above, the AV industry will adapt and update its own performance in response to ongoing NHTSA research and publication about the agency's efforts, nevertheless there will be concerns in some quarters that AVs would have insufficient Federal oversight during this decade of regulatory development, and the States may well face mounting pressure to substitute their own oversight and performance metrics if there is a perceived vacuum of Federal supervision.

In such a case, there would arise a real risk that a patchwork of 50 different State solutions—perhaps even conflicting solutions—would arise. Such a result would be suboptimal, increasing the cost and complexity of compliance for industry without necessarily conferring real safety benefits, and the AV industry may even be led down certain pathways to achieve near-term State compliance at the cost of pursuing medium- and long-term compliance with future Federal requirements.

Altogether, this scenario would risk decel-

"NHTSA can establish a fairly simple test facility regulation, which would identify the environmental ODD testing capabilities that would establish which facilities are able to test which environmental ODDs."

erating AV development in the US, ceding American leadership in this space while potentially giving certain States outsize influence over AV development across the nation.

To address this troublesome possibility, NHTSA and USDOT should assert a stronger leadership role even before the final FMVSS are delivered. Fortunately, the statutory tools to achieve this already exist.

Under Section 30101 (49 USC 30101), NHTSA has authority to carry out "needed safety research and development" in support of prescribing FMVSS, and under Section 30182 (49 USC 30182), the agency is specifically authorized to conduct research and development programs "including activities related to new and emerging technologies that impact or may impact motor vehicle safety" and, in carrying out this duty, to enter into cooperative agreements with a wide variety of entities, including with industry.

In short, NHTSA has broad authority to establish demonstration programs to help research and develop new safety technologies. The authority to create such demonstration programs is not seriously in question: for example, in 1976 Secretary William Coleman proposed a nationwide demonstration program to incentivize passive restraint technologies, and in 1984, NHTSA again considered using its voluntary demonstration program authority to promote those same technologies before electing to take a more directly regulatory approach (see 49 Fed. Reg. 28,962 (July 17, 1984)).

Following this, NHTSA should consider instituting an interim AV Demonstration Program, with the intent that the program accelerate AV technological development across the United States while also accelerating NHTSA's progress in promulgating the FMVSS that will permanently govern the specific performance of AVs on our roadways.

The program could achieve these interrelated goals by maximizing the voluntary participation of AV developers and by collecting data from as many real-world AV operations across the United States as possible (as well as specified closed course or structured testing), to the extent the agency deems necessary to its FMVSS research. To incentivize maximal industry performance, the agency can offer as the enticement harmonized, uniform, nationwide rules for testing and commercial deployment, across all 50 States and territories, such that any participant can test or deploy in any State or territory while satisfying one uniform set of rules.

Importantly, this proposed program would *not* replace or supplement the existing Federal safety rules governing self-certification and exemption; rather, this program would merely provide national uniformity for AV testing and deployment while using vehicles that are either self-certified already or that have valid exemptions or exceptions separately obtained.

NHTSA of course would govern the rules of admission and the rules of participation (as well as those governing suspension), but

> **"Congress has gotten into the act, and there have been numerous bills over the past seven years or so that have sought to increase or modify NHTSA's exemption authority to provide for more commercial-scale deployment."**

should solicit input from the States in so doing. This broad outline would likely satisfy the greatest need for the AV industry today and in the near future: regulatory certainty and one uniform rule for the entire USA.

The AV industry's overall need for uniformity and certainty today heavily outweighs its need for exemptions from NHTSA's other requirements.

The concept for this sort of program would be to provide a regulatory bridge that establishes Federal leadership in the near term and provides industry with certainty and the lead Federal safety agency with cooperation and data to accelerate the date when the permanent set of rules is published. As such, this program is inherently interim or temporary in nature, and the natural termination of the program would occur when NHTSA has substantially completed its first phase of FMVSS governing the specific performance of AVs, at which point oversight would shift from the demonstration program to the ordinary FMVSS process.

The question might be asked: how would a demonstration program create a uniform set of national requirements for AV testing and deployment?

In response, the demonstration program would reflect the agency's determination of a strong national and Federal interest in accelerating technological progress, and a strong Federal regulatory objective in creating flexibility and choice for manufacturers in developing and implementing AV technologies.

A strikingly similar situation was encountered when, in 1984, NHTSA updated certain occupant protection elements of FMVSS 208 (49 CFR 571.208) to expressly provide manufacturers with a wide degree of latitude to develop passive restraint technologies. *See* 49 Fed. Reg. 28,962 (July 17, 1984).

In so doing, NHTSA weighed two main options—pursue a voluntary demonstration program, or update the FMVSS directly. Manufacturers were expressly given the assurance that they could choose to install any of several different types of passive restraint technologies.

One such automaker was challenged in court, and the case went to the Supreme Court. In that case, *Geier v. American Honor Motor Co.*, 529 U.S. 861 (2000), the Court ruled that the agency had successfully articulated an important Federal objective: to "help develop information about the comparative effectiveness of different systems, would lead to a mix in which airbags and other nonseatbelt passive restraint systems played a more prominent role than would otherwise result, and would promote public acceptance." *Id.* at 879.

The Court reasoned that while NHTSA's express preemption authority under Section 30103 (e.g. FMVSS preemption) did not apply, nevertheless the action was subject to the ordinary principles of conflict preemption because the lawsuit would have posed an obstacle to the important Federal regulatory objective that the agency had explicitly identified. *Id.* at 885-86.

A decade later, the Supreme Court revisited the same FMVSS requirement in *Williamson v. Mazda Motor of Am.*, 562 U.S. 323 (2011), and clarified that "[a]t the heart of *Geier* lies our determination that giving auto manufacturers a choice among different kinds of passive restraint devices was a *significant objective* of the federal regulation."

Geier and *Williamson* are not about the FMVSS, per se, but rather the explicit proposition that providing industry with flexibility constituted an imported Federal regulatory objective, and any State law that posed an obstacle to the achievement of this objective was therefore subject to conflict preemption.

Here, were the agency to find that accelerating AV development and providing flexibility and uniform national oversight for AVs is a significant Federal regulatory objective, then there would be a strong argument that any conflicting law that posed an obstacle to the achievement of this Federal objective would be preempted.

Should NHTSA consider taking this route, it might consider whether to expressly limit the reach of preemption such that ordinary damages suits (of the sort brought in ordinary automotive cases) and generally applicable State laws governing the rules of the road, law enforcement, and vehicle registration (excepting only such rules and laws that specifically target AVs) would not be affected.

In so doing, NHTSA might create a level playing field that helps to accelerate AV development across the United States and NHTSA's own efforts in promulgating AV-specific rules on an interim basis, while maintaining the ordinary protections that users of our roadways should expect, until the day arrives when the agency has substantially completed its FMVSS project.

2. Modernizing the FMVSS to Accommodate Novel Designs

The next step that NHTSA can take to further enable AV development in the US is to update and modernize the FMVSS so as to accommodate novel design vehicles. AV developers have proposed a number of novel designs, including zero-occupant cargo vehicles, as well as passenger vehicles that have "campfire" seating arrangements or that lack traditional manual controls.

The existing FMVSS contain a number of performance or design requirements that have been interpreted as presenting regulatory barriers to novel designs. To the extent that such requirements are unnecessary for safety, then such barriers impede development, deprive consumers of the potential benefits adhering to such novel designs, and dissuade developers from making further investments in the US.

This is not a new problem. AV developers have tried a number of approaches to getting novel designs approved. Some companies have submitted petitions for permanent exemptions under Part 555 (49 CFR 555 *et seq.*) and 49 USC 30113, but the agency's statutory authorization limits the exemption to no more than 2,500 vehicles per year from a given manufacturer.

Many companies use the temporary import research and demonstration exemptions available under Part 591 (49 CFR 591 *et seq.*) and 49 USC 30114 that allow companies to test for up to three years or so, or the so-called FAST Act statutory exception for established domestic manufacturers (49 USC 30112(b)(10)) that allow incumbent companies to test prototype vehicles. But none of these exemption/exception pathways provides a bridge to commercial-scale deployment: the Part 555 exemption is capped to low volumes, the Part 591 exemption requires the vehicles to be exported or destroyed after 3 years,[14] and the FAST Act exception expressly prohibits vehicle sales.

To that end, Congress has gotten into the act, and there have been numerous bills over the past seven years or so that have sought to increase or modify NHTSA's exemption authority to provide for more commercial-scale deployment, but none of those efforts has succeeded thus far. Accordingly, the exemption/exception path offers no commercial-scale opportunities at this time.

In the absence of commercial-scale exemptions, AV developers have a fairly clear choice: either abandon novel designs (and the benefits that they promise), or else find a way to self-certify the vehicles to the existing FMVSS. At least one company has publicly stated that it self-certified a novel designed vehicle, and while NHTSA has apparently launched an investigation into that effort, to date NHTSA has not announced any findings. Some others appear to have abandoned their efforts after a long and frustrating wait (and presumably stranding a significant amount of investment).

To address these issues, NHTSA recently announced (on June 13, 2025) its intent to modernize and accelerate the Part 555 exemption review process, and those within industry requiring exemptions undoubtedly will be eagerly looking forward to the enhanced process.

With all of these efforts in mind, the question is whether and to what extent NHTSA should revisit and modernize its existing FMVSS to remove design-related requirements *unnecessary to safety* that have created the perception of barriers to novel vehicle designs.

This is low-hanging fruit, and in fact NHTSA has been working on this problem for quite some time. There are numerous rulemakings in the annual agenda that evince agency efforts to revisit the FMVSS,[15] and the agency has also recently proposed creating a new pilot program (called the "ADS-Equipped Vehicle Safety, Transparency, and Evaluation Program" or "AV STEP" for short) to allow for more flexible testing of novel vehicles. See 90 Fed. Reg. 4130 (January 15, 2025).[16]

Yet to date only one such effort has borne fruit: in 2022, NHTSA finally (and officially) re-published a final rule that updated the 200-series FMVSS (49 CFR 571.201 *et seq.*) to address crashworthiness and occupant protection.

This new rule modified most of the 200-series requirements to allow for more novel design vehicles, including recognizing that the occupant protection rules logically do not apply to vehicles with no designated seating positions (and thus no space for a human occupant who needs protection). *See* 87 Fed. Reg. 18,560 (March 30, 2022). This was a solid first step, but there is much work to be done for the rest of the FMVSS.

What is needed now is for NHTSA to complete its review of the remainder of the existing FMVSS so that design requirements *unnecessary to safety* can be identified and removed as they pertain to novel vehicles. This is not a difficult task—NHTSA has already proven it can do so—but it requires agency leadership to focus staff's efforts on completing the task.

3. Edge Cases & Safety Assurance Program

Finally, NHTSA should consider establishing a new Safety Assurance Program that provides AV developers the ability to share safety critical data so that all developers have the opportunity to learn from the on-road real-world traffic experiences of each.

This program would consist of a confidential venue for sharing critical safety information about real-world encounters, including edge case scenarios, near-misses, and the like, and the intent would be to optimize public safety in AV testing and deployment, while potentially helping to accelerate technological progress.

The program would be modeled in part on NASA's and FAA's programs, and draw from NHTSA's own experience with the Partnership for Analytics Research in Traffic Safety (PARTS) program. And to be perfectly clear, this is about sharing real-world experiences with unusual traffic scenes, not about sharing a company's technology, trade secrets, or solutions or reactions to the unusual scenes.

Each developer would need to create its own solution to the relevant unusual scenes, but by creating a centralized and accessible library of such scenes, the proposed program would make it easier for each AV developer to identify and solve relevant unusual scenes.

In short, developers would continue to compete in terms of developing safe and reliable technology, but in so doing they would be able to draw from an accessible and growing library of unusual traffic scenes against which they can test.

While it is necessary and appropriate for NHTSA to identify *representative* traffic scenarios for the purpose of developing test procedures and performance metrics for future FMVSS, that is not the end of the story.

Americans drive many billions of miles every year, and while the bulk of those miles may be reasonably encapsulated by the representative scenarios, it remains that there are many unusual, rare, even unique traffic scenarios that will be encountered.

While each such scenario might be encountered only in extremely rare circumstances, taken as a whole there are a lot of these "edge cases" (think of them as the tail of the bell curve) even if specific scenarios are themselves rarely repeated. Human drivers may experience only a handful of such incidents in their lives, and that probably creates dangerous situations for them, but AVs are in effect fleets of vehicles driven by a single (software) driver that can be expected to garner far more experience over time than any human. As with human drivers, edge cases can present heightened challenges for AVs, or at least until they have encountered close approximations.

Right now, one of the challenges of developing AV technology involves the lack of sufficient data. Real world traffic is highly variable and complex, and automated vehicle technology needs to ingest a lot of data to understand how to interact with the real world in a safe and reliable manner. And data about edge cases is especially valuable (largely because they are so rare).

It is in the nature of modern ADS that the driving systems learn from what the vehicle encounters (in the real world and in simulation). To address this need, AV developers do a lot of testing—on public roads, on closed courses, and in simulation. But on-road mileage is expensive—developers must pay for the up-front and ongoing costs of the vehicles, their operators, and any associated operational infrastructure—and by definition real-world miles create exposure to real-world risk.

Under our current state of affairs *each* AV developer would be driving on-road for *millions* of miles in order to meet its performance goals and build a statistically significant case.[17] That's because each developer can learn only from its own experiences (a problem magnified for serious edge case scenarios that may happen rarely), or from scenario libraries that are available from industry consultants and partners.

This essay suggests a new state of affairs in which AV development can be accelerated to the benefit of American families and industry alike. NHTSA can and should create a safety assurance program consisting of a database for industry participants to submit scenarios (howsoever defined) with a defined set of regularized data quality parameters to make it possible for other participants to download and re-create the traffic scenario in simulation or on a closed course with relatively little effort.

To encourage candor and effective engagement by AV developers, the data should be anonymized and should be categorized by a relevant set of defined ODD and other (e.g. vehicle type) variables so that participants can more readily determine which sets of scenarios are relevant to their testing and deployment.

Ideally the database would likely be established through a third-party intermediary that establishes and polices the data quality standards, and specific rules would then be established as to under what conditions this data could be shared with regulators.

The database could be supported by a NHTSA grant (e.g. a research grant), and/or some form of cost-sharing arrangement could be established so that participants provide financial support (perhaps linked to the rate at which they download the scenarios). Participation in the database could be voluntary, but NHTSA could encourage participation by requiring AV developers to certify annually whether they are submitting data to the library.

There is a rough model for this already. The PARTS program is a partnership between NHTSA and automakers in which the OEMs submit relevant data concerning the technological attributes, penetration rates, and effectiveness of specified ADAS technologies, along with crash data, to allow for the analysis of those ADAS technologies at reducing various types of crashes.

PARTS is run through an intermediary, and that entity anonymizes data shared with other OEMs and with the regulator (to avoid the chilling effect). There has been interest in the past few years to establish a similar such program for automated vehicles, and it provides a model for designing a program in the US that would be more specifically helpful and effective for the AV industry.[18]

In short, creating an *edge case* data-sharing program would complement the *representative scenario* efforts that NHTSA would be handling more directly, and together these programs could enhance public safety during AV testing while accelerating the development of ADS technologies that promise to save many more lives in the future. And in so doing, NHTSA could help create more regulatory certainty and a clearer pathway to future commercialization to encourage AV developers to continue making the bulk of their AV-related investments in the United States.

IV. Conclusions

This essay will hopefully start a conversation about a more effective framework for assuring public safety through and during the development phase for autonomous vehicles.

The regulators are not in position to issue clear rules for AV performance today, nor will they be in the next few years, but that does not mean that NHTSA cannot make a positive difference in the near term.

Moreover, the task for creating such rules is easier and much more conventional than many have previously considered. NHTSA would be well advised to articulate a concrete vision for the medium-term integration of AVs in the new vehicle fleet and then chart a course in the meantime that provides more regulatory certainty for developers and more confidence among the traveling public, and in turn helps to accelerate the development of AV technologies.

In so doing, the agency can adhere to its core mission—protecting American families as they drive, bike, or walk on our roadways—while encouraging AV developers to continue making many billions of dollars of investments in the US economy in the years to come. Such investments can help reduce traffic congestion and make our highway system more efficient, thereby reducing the (direct) costs of highway expansion and the (indirect) costs of roadway congestion. This a win-win situation, and one that can be done at relatively little expense to the American taxpayer if the regulators can articulate the right vision and take confident steps toward achieving it.

Endnotes

1. For instance, in July 2024, General Motors announced it would pause development of the Origin AV due to regulatory uncertainty. *See* https://investor.gm.com/news-releases/news-release-details/q2-2024-letter-shareholders.

2. Some studies suggest that connected and autonomous vehicles can lead to a system-wide reduction in speeding and an improvement in congestion management. *See*, *e.g.*, Pan, et al., "The impacts of connected autonomous vehicles on mixed traffic flow: A comprehensive review" Physica A: Stat. Mech. & Its Applications, Vol. *635* (Feb. 1, 2024); Shang et al., "Impacts of commercially available adaptive cruise control vehicles on highway stability and throughput" Transport. Research Part C: Emerging Tech., Vol. 122 (Jan. 2021); Abdulsattar, et al. "Characterisation of the impacts of autonomous driving on highway capacity in a mixed traffic environment: an agent-based approach," IET Intelligent Transport Sys. (June 30, 2020); Shladover, et al., "Impacts of Cooperative Adaptive Cruise Control on Freeway Traffic Flow Impacts of Cooperative Adaptive Cruise Control on Freeway Traffic Flow" J. of the T.R.B. *2324* (-1) (Jan. 2012); but *see* Aittoniemi, "Evidence on impacts of automated vehicles on traffic flow efficiency and emissions: Systematic review," IET Intelligent Transport Sys. (June 3, 2022) (suggesting that prioritization on safety could lead to worse congestion outcomes, but acknowledging a high degree of uncertainty).

3. As NHTSA's first special report (Oct. 2020) relates (at 7-8), "According to a survey released by the International Association of Chiefs of Police (Lum et al., 2020), more than half of the more than 1,000 responding agencies established policies explicitly reducing proactive enforcement including traffic enforcement, in both March and May 2020 when the survey was fielded, and nearly three-quarters had policies mandating the reduction in physical arrests for minor offenses. Drawn from their regular communications with statewide law enforcement entities, NHTSA Regional Administrators (personal communication) shared States' self-reported decreases in traffic enforcement, including decreases in seat belt enforcement, impaired driving enforcement, and speed enforcement. The Regional Administrators also indicated State entities were investigating fewer crashes than in previous years."

4. Today, ADAS (Levels 1 and 2 in SAE's taxonomy) technology is widely available—in 2022, most new vehicles sold in the US had at least one automated feature, and nearly half were equipped with L2 or (slightly more advanced) L2+ systems in 2022. Basic ADAS technologies have clearly been embraced by the industry and by consumers, and with the recent promulgation of FMVSS 127, the regulators have begun to integrate them into the framework governing vehicle safety. More advanced ADAS features—so-called L2+ systems in which the vehicle can change lanes and follow navigation without human intervention— are being added to a growing number of new vehicles, but the safety benefits are as yet controversial, with critics pointing out the apparent inconsistency in a system that encourages human attention to wander while demanding constant human supervision.

5. In SAE J3016's taxonomy, there are 5 levels of autonomy, from Level 1 through 5. Levels 1 and 2 describe driver assistance technologies, while Levels 3 and 4 describe autonomous vehicles that can be operated in specified environments, and Level 5 describes a hypothetical fully autonomous vehicle that can be operated without limitation in every

environment.

6. But it's worth bearing in mind that these numbers are still a tiny fraction of total driving. The Federal Highway Administration estimates that in 2023, about 25 billion vehicle miles were driven in California each month.

7. Note that the exact authority to do this with respect to test vehicles owned and operated by a manufacturer is somewhat lacking in that NHTSA's own defects regulations apply only to "vehicles and equipment that have been transported beyond the direct control of the manufacturer," 49 CFR 573.3(a). *See also* 43 Fed. Reg. 60165 (Dec. 26, 1978) (rejecting the contention that the limitation should be modified to exclude vehicles transported "beyond their place of final manufacture" and noting that the reason for the limitation is that "[v]ehicles and equipment within the direct control of manufacturers are virtually assured of remedy of any defect or noncompliance, because they are still within the physical possession of the manufacturer" *id.* at 60165).

8. The exact authority to issue this type of order in this manner can be questioned as an overreach of the agency's enforcement powers (and in practice it more clearly resembles in substance and form the Early Warning Reporting *regulations* coming out of the TREAD Act, *see* 49 CFR Part 579, than any recognizable enforcement action). Perhaps in recognition of this legal vulnerability, or perhaps at the behest of the Office of Information and Regulatory Affairs, NHTSA announced it would pursue a regulation to codify the SGO's requirements. See RIN 2127-AM63, published in the 2024 Spring Regulatory Agenda.

9. For those curious, NHTSA's data shows that there were fewer than 1000 crashes in the United States involving AVs in the four years between July 2021 and May 2025, and fortunately the vast majority of these incidents involved no injuries, with only a handful involving serious injuries. However the data is difficult to interpret because it does not attempt to attribute fault (for instance, the many crashes in which a human driver ran into an AV stopped at a traffic light are each counted as "incidents") and because it also counts all crashes in which the autonomous features were shut off within 30 seconds of the crash. It is also not comparable to public data on police-reported crashes because the SGO covers a much broad swathe of minor incidents that would not normally be expected to be captured by government traffic databases under ordinary circumstances.

10. In addition to the efforts by NHTSA, there has been a significant amount of effort to develop safety assurance for autonomous vehicles by other governmental entities (in particular, the European Union and the UNECE) as well as non-profits such as SAE, ISO, and AVSC, and by entities providing homologation and safety testing assistance, such as Tuv Sud, IAIADA, and the like.

11. *See*, *e.g.*, Rao, S. J., Deosthale, E., Barickman, F., Elsasser, D., & Schnelle, S. (2021, April) An approach for the selection and description of elements used to define driving scenarios (Report No. DOT HS 813 073); Azeredo, P., Tiernan, T., & Najm, W.G. (2021, May) Test procedures with countermeasure timing constraints for intersection movement and left turn assist safety applications (Report No. DOT HS 812 893); Fogle, E., Arquette, T. E., & Forkenbrock, G J. (2021, May) Traffic jam assist draft test procedure performability validation (Report No. DOT HS 812 987); Arquette, T. E., Davis, I. J., Fogle, E. E., Forkenbrock, G. J., & Manahan, T. R. (2021, October) Draft research test procedure performability assessment for

five ADAS variants (Report No. DOT HS 812 983); Fogle, E. E., Forkenbrock, G. J., & Manahan, T. R. (2021, November) Assessing the feasibility of adding additional actors to traffic jam assist test scenarios (Report No. DOT HS 813 169); Draft research test procedure performability assessment for five ADAS variants (Report No. DOT HS 812 983); Rao, S. J., Salaani, K., Howe, G., Barickman, F. S., Elsasser, D., & Schnelle, S. (2023, July) An approach for the selection and description of elements used to define driving scenarios – Part II (Report No. 813 367).

12. *See* S. Wood, et al., "The Potential Regulatory Challenges of Increasingly Autonomous Motor Vehicles" Santa Clara Law Review, Vol. 52, No. 4 (Dec. 20, 2012).

13. This regime is extremely suboptimal and should be altered so that vehicle manufacturers can build new vehicles with such features rather than requiring such modifications to be done retroactively—and thus much more expensively. By enacting this regime, NHTSA is effectively imposing a deeply unfair tax on people with disabilities. The agency should consider supplementing this system by creating a new class of vehicles—let's call them "accessibility vehicles" for the time being—and then upgrading the relevant FMVSS to provide for specific carveouts from the FMVSS as are necessary to allow original manufacturers to build accessible vehicles at the factory at much lower cost.

14. Note that NHTSA recently (on April 24, 2025) published an open letter to AV developers announcing that the agency would begin processing Part 591 applications for research and demonstration exemptions for domestic as well as imported vehicles.

15. *See*, *e.g.*, "Framework for Automated Driving Systems Safety" ANPRM, RIN 2127-AM15 (Spring 2024 Agenda); "Considerations for Telltales, Indicators and Warnings in Vehicles Equipped With Automated Driving Systems" ANPRM, RIN 2127-AM07 (Spring 2024 Agenda); "Exemption and Demonstration Framework for Automated Driving Systems" NPRM, RIN 2127-AM60 (Spring 2024 Agenda); "Facilitating New Automated Driving System Vehicle Designs for Crash Avoidance Testing" ANPRM, RIN 2127-AM00 (Spring 2024 Agenda); "Assessment of FMVSS Test Procedures" ANPRM, RIN 2127-AM04 (Spring 2024 Agenda).

16. It is unclear what the future might hold for the proposed AV STEP program, given that after nearly four years of apparent effort, it was finally published only 5 days before the new Administration took office. The proposal offers some relief to AV manufacturers—particularly allowing new entrants obtain test exemptions for domestically manufactured AVs and providing some relief against the "make inoperative" prohibitions that can limit the extent to which a manufacturer may modify a certified vehicle—but it imposes a significant amount of red tape and data collection requirements that might limit the program's broader appeal to industry. Notably, the proposal expressly disclaims any intent to preempt State law requirements, 90 Fed. Reg. at 4142, limiting its impact and failing to stem the emerging 50-state legal patchwork that creates rising barriers and costs for developers. Importantly, NHTSA recently announced (on April 24, 2025) that it would update the "Box 7" research exemption process (from Part 591) to include domestically manufactured vehicles—a common-sensical and long-awaited reform that would finally put domestic vehicles on the same legal footing as imports—but this would deprive the AV STEP program proposed by the previous administration of one of its most significant potential benefits.

17. For instance, it has been suggested that to demonstrate that an AV is 20% safer than a human driver as a statistical matter, it would be necessary to test an AV for 11 billion miles. See N. Kalra and S. Paddock, Driving to safety: How many miles of driving would it take to demonstrate autonomous vehicle reliability? Transportation Research Part A: Policy and Practice, Volume 94, December 2016, Pages 182-193.

18. Moreover, there are third parties who partner with the AV industry to develop testable scenarios to assist with verification and validation, and while a NHTSA-approved data sharing initiative would provide a credible assist to the AV industry in terms of accelerating development and reducing public risk, it's likely that AV developers would continue to develop their own testable scenarios and to use those developed by their partners.